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UCRL-WEB-215847

Ultra-Wideband Radio Communication Real Field Experiments

This appendix summarizes the results of a set of experiments we performed with the UWB-TR radios developed the Lawrence Livermore National Laboratory (LLNL), as a part of the Secure Wireless Communications project. The experiments were jointly conducted by the LLNL, Naval Post Graduate School (NPS), and the U.S. Special Operations Command (SOCOM) to demonstrate through the wall communications capability of UWB-TR receivers. The UWB radios used in the conducted experiments were prototype board level design of conventional transmitted-reference receivers discussed in chapter 3 of this dissertation. Two different experiments were conducted to validate the performance of these radios in harsh propagation environments. We summarize each these experiments and their results in the following sections.

C.1 Experiment at Fort Ord Facility

Our first real field experiment was conducted on 8/31/04 at U.S. Army's training base at Fort Ord, located in the Montery Bay Peninsula in central California. The Fort Ord experimental site is an ideal test site for the testing the performance of advanced

communication systems in an urban environment. Fig. C-1 and Fig. C-2 show parts of Fort Ord village.

Figure C-1: Fort Ord Village

Figure C-2: Another view of Fort Ord Village

In this preliminary experiment we focused on through-the-wall communication performance of UWB radios. Our first generation of UWB-TR transceiver hardware prototype was tested for transmission and reception of low data rate text data through thick concrete walls. The transceiver was designed for transmission and reception of UWB pulses in the range of 1.2 to 1.6 GHz at a 1 mW total power output. Fig. C-3 and C-4 show the UWB-TR prototype transceiver and it's setup in a building at Fort Ord military camp.

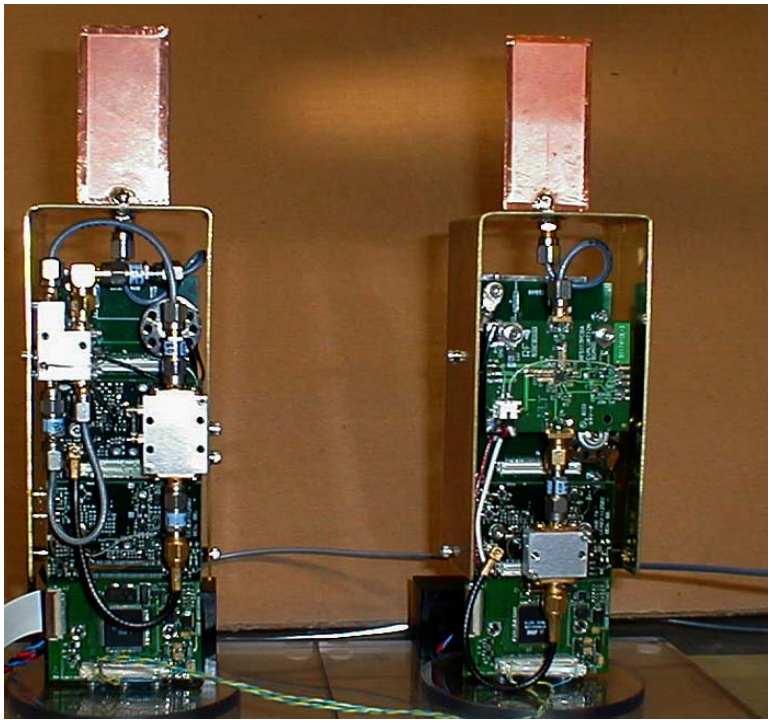

Figure C-3: First generation UWB-TR transceiver prototype system

Figure C-4: The testing environment of the UWB-TR system in Fort Ord's concrete buildings

Building structure at Fort Ord provides a harsh propagation environment for wireless communication systems. The walls were made of 8 to 10 inches thick concrete blocks. Our transceivers performed successful through the wall communications with at least 2 walls. Text messages were transmitted and received with no error by penetrating through walls. The experiment with higher number of walls showed partial success depending on the antenna location, height, and directionality. Fig. C-5 and C-6 represents the thickness of the concrete walls that the UWB system was tested against.

Figure C-5: Representation of the walls inside Fort Ord

Figure C-6: Thickness of the concrete walls in Fort Ord facility equal to the width of a typical notebook (~ 8.5 inches)

C.2 Experiment at Naval Postgraduate School[1]

A second set of experiments was conducted at NPS Halligan Hall on Nov. 19, 2004. In this experiment, our UWB-TR transceivers were integrated in a long-range mesh network of WLAN nodes provided by NPS researchers. The purpose of integrating our UWB radios in NPS mesh network was to take advantage of our through the wall communication capability for transferring video images through building walls to outside WLAN nodes. The data was then communicated through a UWB-WLAN interface to the rest of the WLAN nodes across NPS campus to a room called Gigalab in a building called Root Hall. The diagram in Fig. C-7 illustrates the configuration of the nodes, bridges (join points), and UWB equipment that was used in the experiment in the NPS quad.

[1] This section is provided by Carlos (Kique) Romero

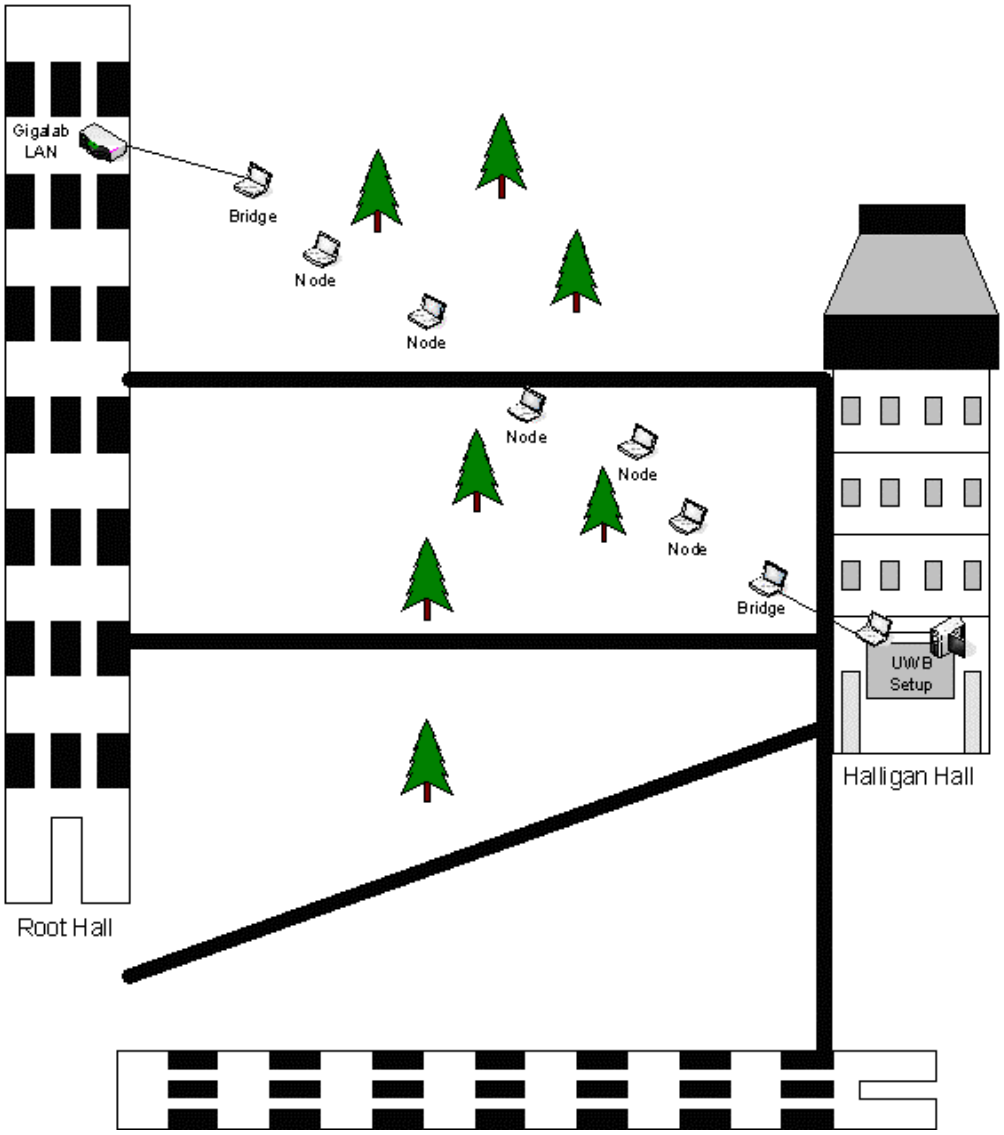

Figure C-7: UWB Test Set Up in NPS Quad

The node/bridge configurations were as follows:

- Dell Latitude X300, 1.4 GHz Pentium M processor, 632 MB RAM and an Orinoco Gold 802.11b/g Wireless PCMCIA NIC running at 100% transmit

power. The operating systems were Windows XP Professional. (Nodes/Bridges)

- Dell Dimension 4500, 2.4 GHz Pentium 4 processor and 1 GB RAM. The operating system was Windows Server 2003. (Gigalab NOC/LAN)

There existed a total of 5 Mesh nodes with two Mesh bridges connecting the Gigalab LAN with the UWB test set. The distances between nodes and bridges were approximately 50 feet. Some of the network characteristics captured was:

- Throughput range of 6 kb/s – 180 kb/s.
- Response times of 0 ms – 296 ms.

Our UWB-TR radio was set up at the basement of Halligan Hall. The blueprint of the basement is shown in Fig. C-8 to illustrate the UWB setup location and environment.

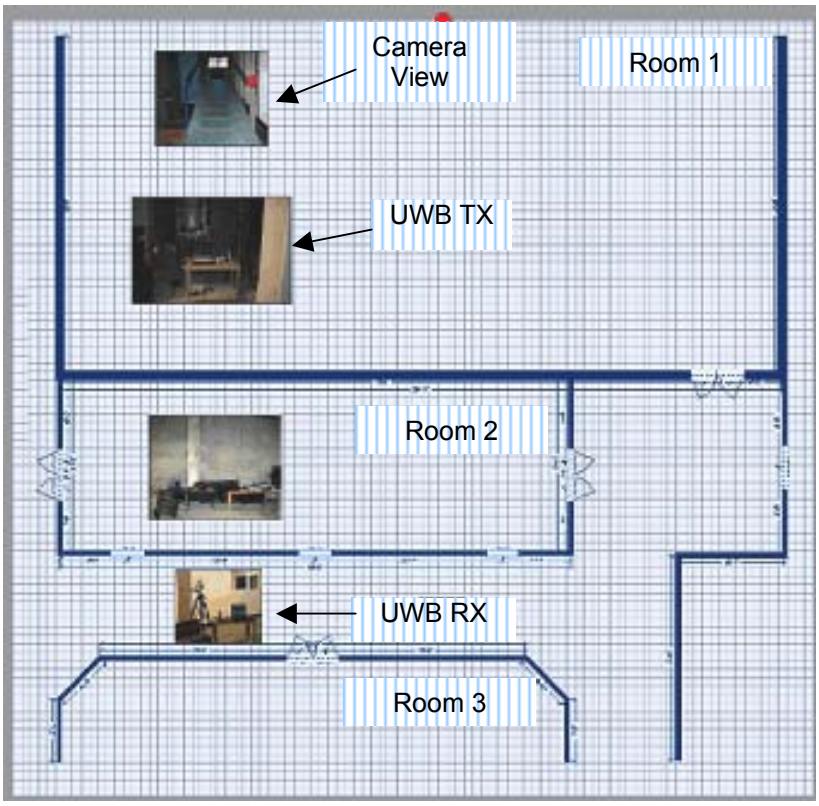

Figure C-8: Halligan Hall basement blueprint to illustrate UWB setup

The diagram in Fig. C-9 shows more details of the UWB-TR test setup including the wall measurements and distances.

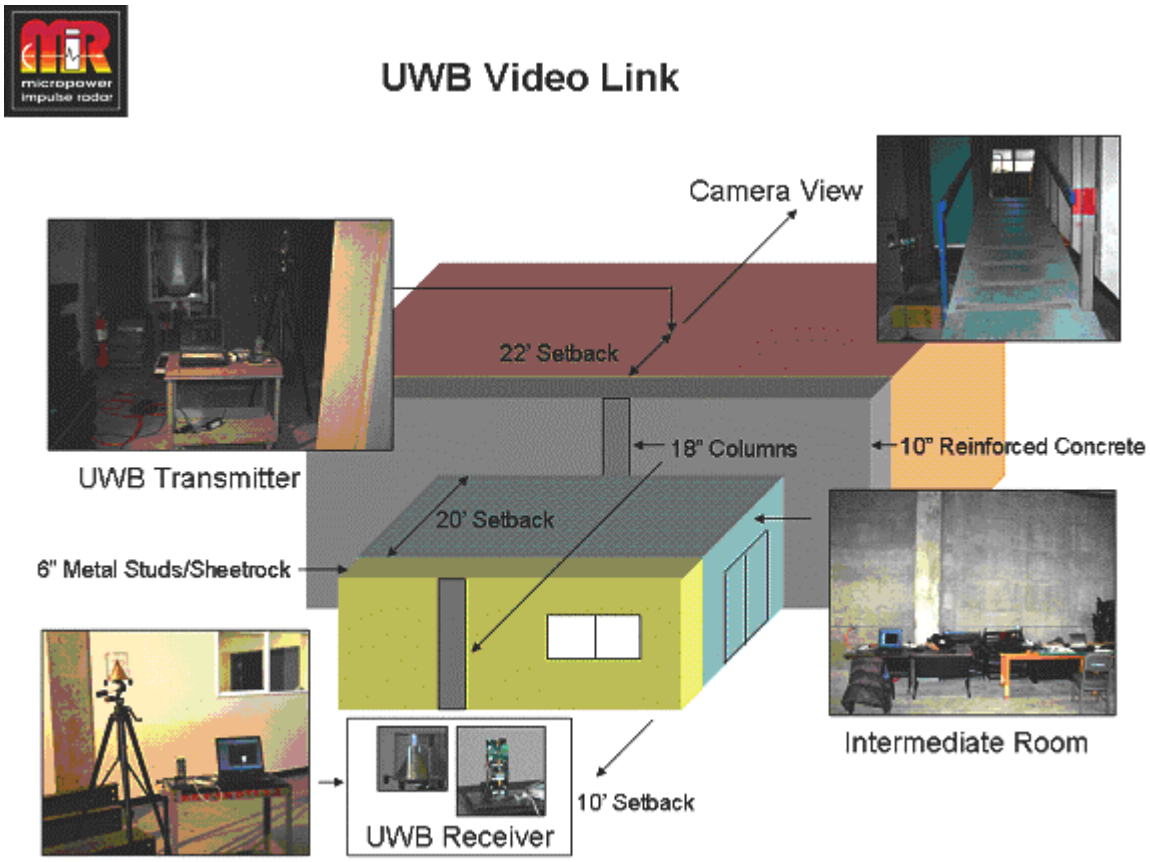
UWB Video Link
Camera View
22' Setback
18" Columns
10" Reinforced Concrete
UWB Transmitter
20' Setback
6" Metal Studs/Sheetrock
Intermediate Room
10' Setback
UWB Receiver

Figure C-9: UWB Test Setup in Halligan Hall basement

The setup was comprised of a our first generation UWB-TR transmitter and receiver set transmitting live streaming video of a passageway through multiple walls. The distance between the transmitter and receiver was approximately 56 feet. The transmission penetrated two walls and across three rooms. One wall was constructed of 10 inch reinforced concrete and the second wall was 6 inches of sheetrock with metal studs. The transmitter for this experiment was transmitting in a frequency range of 1.2 – 1.6 GHz at a 1 mW total power output. Fig. C-10 illustrates the UWB-TR receiver and the transmitted video stream.

Figure C-10: UWB-TR Receiver

The UWB transmitted data from the video stream was displayed on a laptop. Due to interface issues the UWB data stream was not directly transmitted over the Mesh. A separate laptop with a Canon VC-C4 video camera took live video of the UWB display which was then transmitted over the Mesh to the Gigalab LAN. Figure C-11 shows another view of the UWB receiver used in this experiment.

Figure C-11: Another view of UWB-TR receiver setup

The distances traveled and the obstacles that the UWB transmissions were able to penetrate successfully, proved that the UWB-TR technology used will have a great impact in a tactical environment. The UWB transmitter and its setup was very similar in appearance to the UWB receiver shown in Fig. C-11. The images shown in Fig. C-12 and C-13 illustrate the transmitted and received image through the UWB link on laptop monitors.

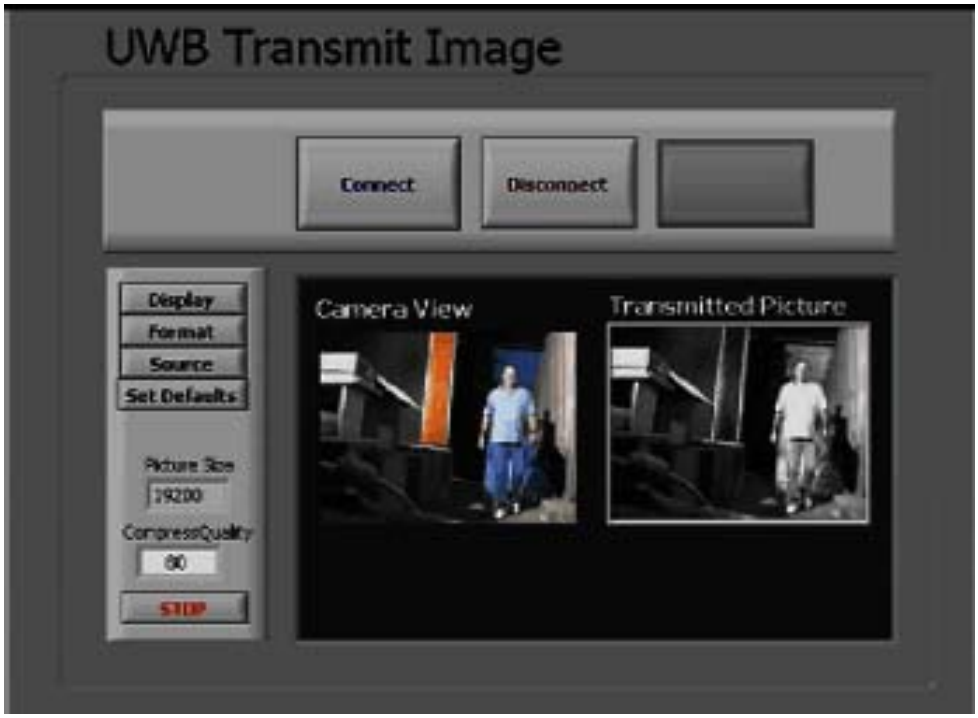

Figure C-12: Camera view and UWB transmitted image

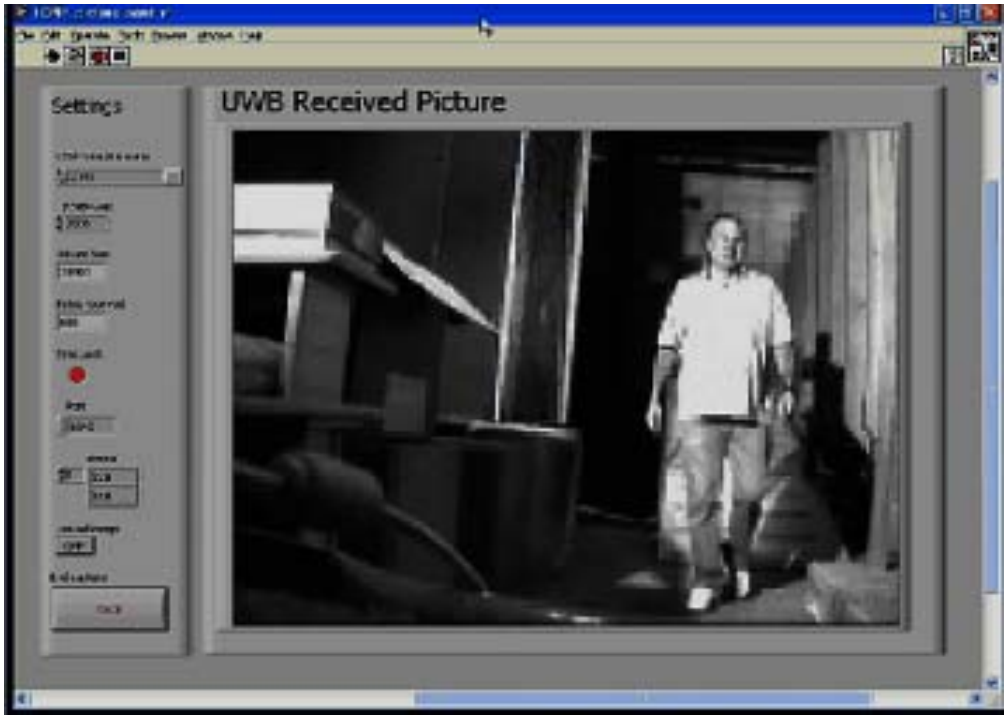

Figure C-13: UWB received image through 2 walls

Through the successful transfer of live video images from across the NPS quad using UWB radios, the images were viewed at Gigalabs on NPS's Situational Awareness (SA) screen shown in Fig. C-14.

Figure C-14: Situational Awareness view of UWB Video in Gigalabs

The players involved in this situation were the Gigalab Network Operation Center (NOC), the node in the UWB test set area, FT Bragg, and SOCOM. The FT Bragg and SOCOM SA nodes helped demonstrate the ability of the SA program to successfully collaborate with remote sites over 3000 miles away in real time. The

UWB video stream was being observed at FT Bragg, NC and at SOCOM in Tampa, FL. A chat session was also being operated concurrently with the video stream using the SA program. Fig. C-15 shows another view of live UWB video transfer on Situational Awareness screen.

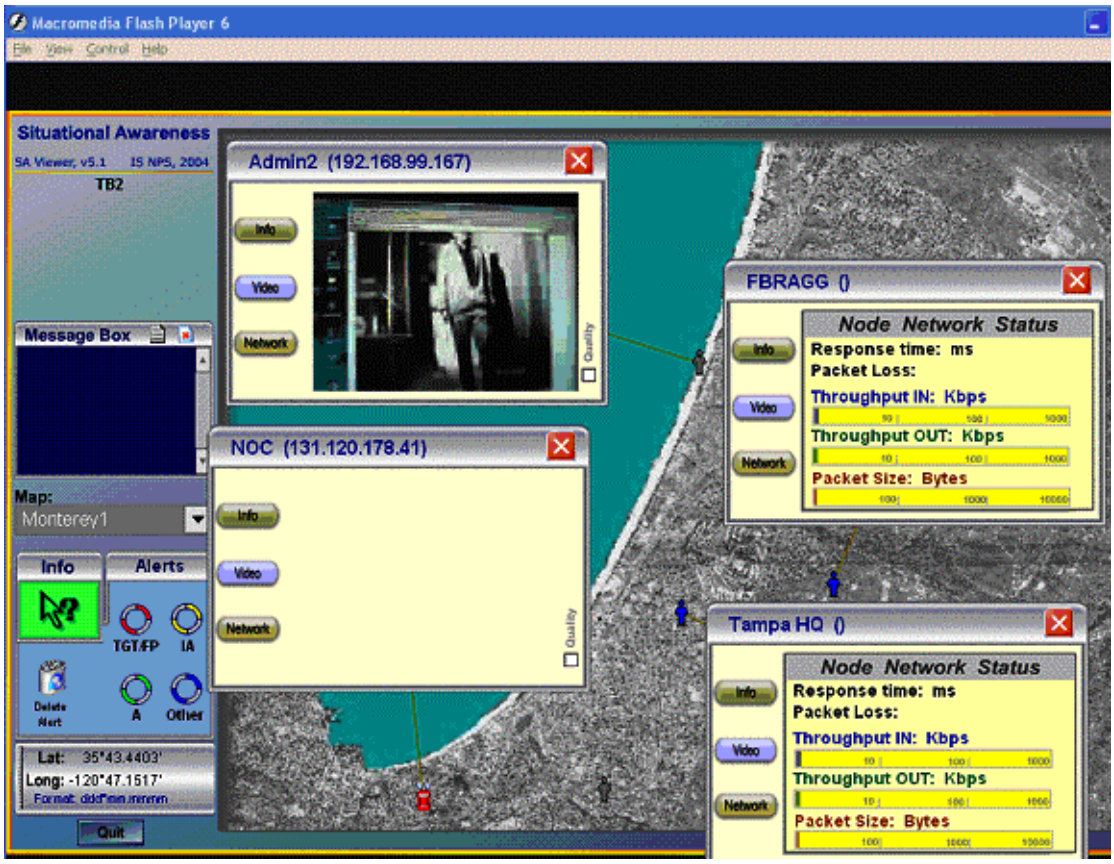

Figure C-15: Another SA view with updated video image